The use of avian feeding guilds to detect small-scale forest disturbance: a case study in East Kalimantan, Borneo

BEN WIELSTRA, TJALLE BOORSMA, SANDER M. PIETERSE & HANS H. DE IONGH

Finding suitable indicators to monitor the state of disturbance of tropical forests is a challenge. Avian feeding guilds are a promising candidate and we test their practical usefulness. We use checklists compiled during short surveys. The observed species are classified into avian feeding guilds based on a combination of diet and foraging layer. We compare avian feeding guild structure of two forests exploited on a small scale (traditional community forest or *hutan adat*) with an undisturbed control area. Fieldwork was conducted in duplicate (in two rounds, by different observers) in East Kalimantan (Indonesian Borneo). Four avian feeding guilds were found to show differences in species numbers between the disturbed and control sites: terrestrial insectivores and arboreal nectarivores are more numerous, whereas understorey insectivores and arboreal insectivores are less numerous in terms of number of species. Of these four, understorey insectivores were considered to be the most informative, as understorey species are surveyed most effectively and as the guild contains a relatively large number of species. Standardised monitoring of avian feeding guilds yields valuable information on the state of disturbance of forests, and species checklists based on short surveys are a suitable method to obtain the required data. We recommend including avian feeding guilds in standardised monitoring programmes and discuss possible improvements for a study in a larger framework.

INTRODUCTION

Tropical forests contain the majority of the planet's biota. The persistence of the world's tropical forests is crucial to the conservation of global biodiversity, but these forests are facing ever-increasing anthropogenic pressure (Hansen *et al.* 2010). Fundamental to the management of forests is to understand the state of disturbance they experience. Monitoring should yield scientifically sound information on the condition of the forests' biodiversity and potential changes therein (Noss 1999). However, developing a clear and practical monitoring system is challenging.

Monitoring all components and interactions of an ecosystem is impossible. Instead, indicators are used: a selection of taxa for which the response (to a certain input, such as disturbance) is expected to reflect the state of the ecosystem as a whole (e.g. Caro & O'Doherty 1999). Habitat degradation can be an insidious process, slowly eroding biodiversity. In order to function as an early warning system, indicators must be sensitive enough to detect the first signs of overall ecosystem deterioration.

Avian feeding guilds have previously been suggested as a suitable indicator (e.g. Ghazoul & Hellier 2000). A feeding guild can be defined as 'a group of species that exploits the same class of environmental resources in the same way' (Root 1967). Such a clustering of individual species into groups is not susceptible to change due to e.g. taxonomic progress or improved insight into population size, which is the case for other criteria such as endemism and Red List status. Birds are particularly suitable, as they are relatively easy to survey and their ecology is relatively well understood (Bibby *et al.* 2000, Gray *et al.* 2006).

The objective of this study is to find an indicator which is sensitive enough to register slight levels of disturbance and for which the required data can be collected against relatively low costs and effort. We assess the potential of avian feeding guild data, by comparing the avifaunal composition of forest disturbed on a small scale with an undisturbed control site.

Study area

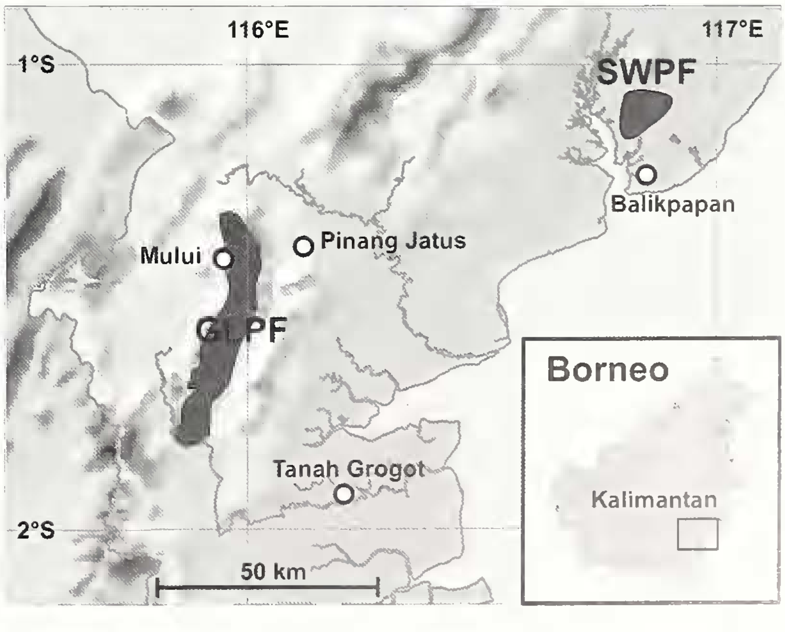
We present a case study from Borneo. Fieldwork was carried out in two lowland rainforest areas in East Kalimantan (Indonesian Borneo): Gunung Lumut Protection Forest (GLPF) and Sungai Wain Protection Forest (SWPF) (see Figure 1).

Hutan adat is the Indonesian term for forest claimed by customary right, where access and control over forest resources are governed by the local community (van der Ploeg & Persoon 2007). *Hutan adat* is subject to extraction of non-timber forest products and selective logging for personal use. In theory, *hutan adat* is protected from large-scale exploitation, because its sustainable use is in the best interest of the villagers. However, in practice short-term benefits might entice villagers to e.g. convert *hutan adat* to shifting cultivation (*ladang*).

The selected study sites at GLPF are the *hutan adat* of the villages Mului and Pinang Jatus. The *hutan adat* of Mului is situated in GLPF, whereas the *hutan adat* of Pinang Jatus partially overlaps with GLPF. *Hutan adat* of both Mului and Pinang Jatus is subject to selective logging (for personal use), hunting, rattan and bamboo harvesting, bird trapping and the gathering of fruit, honey and firewood (Pieterse & Wielstra 2005, van der Ploeg & Persoon 2007). This disturbance has not been quantified. We consider the *hutan adat* of Mului and Pinang Jatus to represent forest disturbed on a small scale (Pieterse & Wielstra 2005).

Although part of SWPF has suffered from 1998 forest fires and encroachment, its 4,000 ha core has remained intact (Fredriksson & Nijman 2004). This core, consisting of pristine rainforest, is only accessible to researchers and therefore considered virtually undisturbed. SWPF was chosen as a control site, because there are no known undisturbed tracts of rainforest in GLPF (or elsewhere

Figure 1. Geographical location of the study areas in East Kalimantan. SWPF = Sungai Wain Protection Forest; GLPF = Gunung Lumut Protection Forest.



in SE Kalimantan, for that matter). This study design potentially introduces other factors, besides disturbance, varying between test and control sites. However, given the logistical constraints, SWPF was the most suitable control site available.

Bird surveys have previously been carried out in SWPF (e.g. Slik & van Balen 2006). All records collected during these surveys (including the present study) have been combined into a checklist (G. Fredriksson *in litt.*). This checklist is here regarded as approaching the total avifauna present in SWPF, and is referred to as the 'total checklist'. As opposed to SWPF, the avifauna in GLPF had never previously been surveyed (Wielstra & Pieterse 2009).

METHODS

Surveys of the three study sites were conducted in two rounds by different observers, in order to assess repeatability of results. We refer to the individual surveys as 'visits'. During the six visits (mean 15±4.7 days) we made interim species checklists. These checklists were based on data collected during point-transect and line-transect counts, complemented by random observations. All fieldwork was carried out between February and May in 2005 (Pieterse & Wielstra 2005) and 2007 (Boorsma 2008). We did not have any previous field experience with the region's birds. To avoid negative effects of a learning curve, the following precautions were taken:

- In order to train bird identification skills, literature and sound recordings were studied before commencing fieldwork and a seven-day learning period was spent in the field prior to collecting data.
- Sound recordings were made, so unknown sounds could be identified at a later time (Parker 1991; Bibby *et al.* 2000).
- Study sites were visited in opposite order: GLPF Pinang Jatus–GLPF Mului–SWPF by Pieterse & Wielstra (2005) and *vice versa* by Boorsma (2008).

Species were assigned to avian feeding guild based on a combination of preferred diet and foraging layer. Birds were classified as: nectarivore, insectivore, carnivore (raptor/piscivore), frugivore or a combination of these. Foraging layers were: terrestrial, understorey (0–10 m) or arboreal (>10 m). Our analysis only included resident, forest-dependent species. Species preferring open areas were excluded because they were expected to respond positively to disturbance, despite belonging to the same avian feeding guild (Lambert & Collar, 2002). Aerial feeders, raptors and nocturnal species were also excluded, as these require separate survey methods (Bibby *et al.* 2000, Slik & van Balen 2006). Wintering migrants were excluded in order to prevent a seasonal bias. Assigning ecological traits to species was based on Lambert (1992), Thiollay (1995), Smythies & Davison (1999), Lambert & Collar (2002) and Slik & van Balen (2006).

The comparability among the three sites was evaluated based on (1) number of species recorded during individual visits and (2) number of species recorded per study site (combining both visits). The efficiency of our visits was assessed by determining the overlap in species recorded between (1) visits per study site, and (2) the total checklist of SWPF versus the data derived from our own visits. Differences in avian feeding guild structure were analysed, based on a comparison of the data from the disturbed area (the two sites in GLPF) and the undisturbed control area (SWPF).

RESULTS

The complete list of forest-dependent resident lowland species recorded with certainty, and their division into avian feeding guilds, can be found in the appendix. The number of species recorded during the individual visits and the cumulative number of the two visits per site is provided in Table 1. On average, 112.3±5.1 species were observed during individual visits and 154.3±2.1 species were observed per study site. The species overlap between the two visits per study site is c.70% (Table 1). Similarly, the species overlap between pairs of study sites is c.70% (Table 2).

Table 1. Overlap of the number of species recorded during the two visits per study site. SWPF = Sungai Wain Protection Forest; GLPF = Gunung Lumut Protection Forest; PJ = Pinang Jatus; M = Mului; visit I = data from Pieterse & Wielstra (2005); visit II = data from Boorsma (2008); cumulative = the total number of species recorded for both visits combined; overlap = the species shared between visits, with the percentage of the cumulative number in parenthesis.

	visit I	visit II	cumulative	overlap
SWPF	120	110	134	96 (71.6)
GLPF PJ	113	111	134	90 (67.2)
GLPF M	105	115	129	91 (70.5)

Table 2. Overlap in the number of species recorded at the different study sites. See Table 1 for explanation of abbreviations and terms.

	cumulative	overlap
SWPF vs GLPF PJ	155	114 (73.6)
SWPF vs GLPF M	156	107 (68.6)
GLPF PJ vs GLPF M	152	112 (73.7)

The species richness and avian ecological characteristics of the total checklist and our survey data for SWPF are compared in Table 3. We recorded fewer species than are noted on the total checklist (71.0% and 65.1% during the first and second visit). When looking

Table 3. Comparison of the survey data and the total checklist of SWPF (Sungai Wain Protection Forest). Visit I = data from Pieterse & Wielstra (2005); visit II = data from Boorsma (2008). The data are divided into three ecological partitions: foraging layer (A = arboreal; U = understorey; T = terrestrial), diet (F = frugivore; I = insectivore; C = carnivore; N = nectarivore; combinations possible) and avian feeding guild (a combination of foraging layer and diet). See the appendix for the assignment of species to ecological partition. Integers represent the number of species recorded; the percentage of the total checklist is in parenthesis.

Ecological partition	SWPF visit I	SWPF visit II	SWPF visit I & II cumulative	SWPF total checklist
Foraging layer				
A	53 (60.2)	49 (55.7)	64 (72.7)	88
U	55 (88.7)	48 (77.4)	56 (90.3)	62
T	12 (63.2)	13 (68.4)	14 (73.7)	19
Diet				
F	8 (61.5)	8 (61.5)	11 (84.6)	13
FI	22 (81.5)	22 (81.5)	25 (92.6)	27
FC	5 (71.4)	6 (85.7)	6 (85.7)	7
I	74 (76.3)	64 (66.0)	80 (82.5)	97
N	8 (38.1)	8 (38.1)	9 (42.9)	21
IC	3 (75.0)	2 (50.0)	3 (75.0)	4
Avian feeding guild				
AF	7 (58.3)	7 (58.3)	10 (83.3)	12
AFI	8 (66.7)	8 (66.7)	10 (83.3)	12
AFC	5 (71.4)	6 (85.7)	6 (85.7)	7
AI	30 (71.4)	24 (57.1)	34 (81.0)	42
AN	3 (20.0)	4 (26.7)	4 (26.7)	15
UFI	10 (100.0)	9 (90.0)	10 (100.0)	10
UI	37 (88.1)	33 (78.6)	38 (90.5)	42
UIC	3 (75.0)	2 (50.0)	3 (75.0)	4
UN	5 (83.3)	4 (66.7)	5 (83.3)	6
TF	1 (100.0)	1 (100.0)	1 (100.0)	1
TFI	4 (80.0)	5 (100.0)	5 (100.0)	5
TI	7 (53.9)	7 (53.9)	8 (61.5)	13
Total	**120 (71.0)**	**110 (65.1)**	**134 (79.3)**	**169**

Table 4. The avian feeding guild structure of the survey data for the different study sites. See Table 1 for explanation of site abbreviations and terms, and Table 3 for guild abbreviations. For each visit, the percentage of the cumulative number of species is stated in parenthesis. See the appendix for the assignment of species to ecological partition.

Avian feeding guild	SWPF visit I	SWPF visit II	SWPF overlap	SWPF cumulative	GLPF PJ visit I	GLPF PJ visit II	GLPF PJ overlap	GLPF PJ cumulative	GLPF M visit I	GLPF M visit II	GLPF M overlap	GLPF M cumulative
AF	7 (70.0)	7 (70.0)	4 (40.0)	**10**	11 (100.0)	10 (90.1)	10 (90.1)	**11**	11 (100.0)	8 (72.7)	8 (72.7)	**11**
AFI	8 (80.0)	8 (80.0)	6 (60.0)	**10**	7 (87.5)	7 (87.5)	6 (75.0)	**8**	7 (70.0)	10 (100.0)	7 (70.0)	**10**
AFC	5 (83.3)	6 (100.0)	5 (83.3)	**6**	8 (100.0)	7 (87.5)	7 (87.5)	**8**	5 (83.3)	6 (100.0)	5 (83.3)	**6**
AI	30 (88.2)	24 (70.6)	20 (58.8)	**34**	27 (87.1)	21 (65.6)	17 (53.1)	**31**	26 (93.0)	26 (93.0)	24 (85.7)	**28**
AN	3 (75.0)	4 (100.0)	3 (75.0)	**4**	9 (100.0)	6 (66.7)	6 (66.7)	**9**	7 (77.8)	9 (100.0)	7 (77.8)	**9**
UFI	10 (100.0)	9 (90.0)	9 (90.0)	**10**	6 (66.7)	8 (88.9)	5 (55.6)	**9**	8 (80.0)	9 (90.0)	7 (70.0)	**10**
UI	37 (97.4)	33 (86.8)	32 (84.2)	**38**	25 (80.7)	28 (90.3)	22 (71.0)	**31**	25 (78.1)	28 (87.5)	21 (65.6)	**32**
UIC	3 (100.0)	2 (66.7)	2 (66.7)	**3**	2 (100.0)	2 (100.0)	2 (100.0)	**2**	1 (50.0)	2 (100.0)	1 (50.0)	**2**
UN	5 (100.0)	4 (80.0)	4 (80.0)	**5**	4 (80.0)	5 (100.0)	4 (80.0)	**5**	6 (85.7)	6 (85.7)	5 (71.4)	**7**
TF	1 (100.0)	1 (100.0)	1 (100.0)	**1**	1 (100.0)	1 (100.0)	1 (100.0)	**1**	1 (100.0)	1 (100.0)	1 (100.0)	**1**
TFI	4 (80.0)	5 (100.0)	4 (80.0)	**5**	4 (66.7)	5 (83.3)	3 (50.0)	**6**	2 (66.7)	2 (66.7)	1 (33.3)	**3**
TI	7 (87.5)	7 (87.5)	6 (75.0)	**8**	9 (69.2)	11 (84.6)	7 (53.9)	**13**	6 (60.0)	8 (80.0)	4 (40.0)	**10**
Total	120 (89.6)	110 (82.1)	96 (71.6)	**134**	113 (84.3)	111 (82.2)	90 (67.2)	**134**	105 (81.4)	115 (89.2)	91 (70.5)	**129**

at foraging layers, it becomes apparent that understorey species were relatively better covered than arboreal and terrestrial species (i.e. a higher percentage of the total number of species present was recorded). When looking at avian feeding guild structure, arboreal nectarivores and terrestrial insectivores were noticeably poorly covered.

Differences in avian feeding guild structure between visits and sites are presented in Table 4. Understorey insectivores and arboreal insectivores in particular showed a lower number of species in disturbed forest, whereas numbers of species of arboreal nectarivore and terrestrial insectivore were higher in disturbed forest.

DISCUSSION

Comparability and efficiency of surveys

We did not collect a dataset of sufficient size to test our results statistically (this would require more disturbed and control sites to be visited). We thus provide a qualitative interpretation of our data. The number of species observed at the different study sites is similar. This applies to both the individual visits and their cumulative number. Furthermore, the study sites all share a large proportion of their species and no site is more similar to one than to the other. We argue this allows us to make comparisons among the study sites.

The overlap in species recorded during the two visits per study site is substantial, meaning that different observers can converge on the same results in a short time-span. Furthermore, comparing our survey data with a total checklist reveals that the majority of species present is recorded during short surveys. We conclude that short surveys are efficient and reproducible.

Response of avian feeding guilds to small-scale disturbance

When taking ecological preferences into account, differences between the disturbed sites and the undisturbed control site come to light. Most avian feeding guilds do not show a clear difference, but some guilds respond to disturbance in a consistent fashion. The number of understorey insectivores and, less clearly, arboreal insectivore species is lower in the disturbed sites than in the undisturbed site. For arboreal nectarivores and, less clearly, terrestrial insectivores, the opposite is true.

We argue that the smaller the number of species included in a particular avian feeding guild is, the larger the effect of missing one or two species by chance would be. Therefore results for small avian feeding guilds would be less reliable. Understorey and arboreal insectivores are by far the most speciose avian feeding guilds. Understorey species in general are covered well during short surveys, while arboreal and terrestrial species are relatively poorly covered. Higher conspicuousness of understorey species owing to factors such as behaviour, distance to observer, and level of concealment by vegetation may explain this (e.g. Bibby *et al.* 2000). Therefore, of the four avian feeding guilds which show differences between the disturbed and undisturbed sites, understorey insectivores appear to yield the most reliable information for monitoring purposes.

Comparison with previous studies

This study particularly focuses on the effects of small-scale disturbance. It is the first to compare traditional forests or *hutan adat* with undisturbed forest. Previous studies have looked at the effects of several kinds of large-scale disturbance, i.e. fragmentation, forest fires and logging. We compare such studies conducted in Asia with our own results to determine the similarities and differences in the responses shown by birds.

Fragmentation seems to affect virtually all species negatively. Forest fragments, even relatively large patches, lose a significant number of species over time (Lambert & Collar 2002). Van Balen (1999) found that forest interior species are more dependent on larger forest patches for survival than forest-edge, open-area and urban species. Hunting particularly affects large birds such as hornbills, doves and pheasants (Meijaard *et al.* 2005), whereas the trapping of birds for the pet industry focuses on songbirds (Jepson & Ladle 2005). Forest fires were found to have a positive effect on understorey insectivores, a result contrary to previous studies and perhaps explicable in part by differences in sampling method, forest recovery time and distance to unburned forest (Slik & van Balen 2006).

Logging affects insectivores in general (Gray *et al.* 2006), and understorey (de Iongh *et al.* 2007) and terrestrial (Cleary *et al.* 2007, de Iongh *et al.* 2007) insectivores in particular. In the case of arboreal and understorey insectivores, our results point in the same direction, but terrestrial insectivores actually show a slight increase in disturbed forest in our dataset. However, care should be taken when interpreting this result, as this guild contains few species (mainly pittas and wren-babblers). Stimulation of flowering by disturbance (e.g. through increased sunlight due to canopy opening) can lead to a temporary increase in nectarivores (Ghazoul & Hellier 2000, Lambert & Collar 2002, Slik & van Balen 2006). Our data suggest an increase of arboreal nectarivores under disturbance, but do not show a difference for understorey nectarivores. Frugivores show varying responses to disturbance (Ghazoul & Hellier 2000, Gray *et al.* 2006), but our data do not show a clear response at all.

The different types of forest disturbance should not be seen independently of each other (Lambert & Collar 2002). For example, logging can cause fragmentation and makes forest areas more susceptible to fire. Moreover, logging makes the forest more accessible, which in turn could produce an increase in hunting.

A major difference among the studies reviewed in this paper concerns the partitioning of the recorded avifauna into groups. This makes comparing studies difficult. Some studies (e.g. Lambert 1992) discuss specific taxonomic groups, such as woodpeckers, or even more specific, such as 'wren-babblers'. In our study, species belonging to these groups are classified into broader feeding guilds (e.g. woodpeckers are classified as either understorey or arboreal insectivore). Even when data are divided into feeding guilds, there are major differences among studies in how this is to be accomplished (Simberloff & Dayan 1991). For example, some studies also include foraging method or body mass. This signifies a trade-off: while it could be informative to partition a dataset into more classes, increasing the number of classes does reduce the number of species in each class.

Conversely, some studies do not distinguish between open-area and forest-dependent species. Although forest-dependent species respond negatively to forest disturbance, open-area species respond positively. We would argue that this distinction should be explicitly taken into account. The increase in understorey insectivores reported by Cleary *et al.* (2007) probably relates to an increase of open-area species (such as tailorbirds). Comparability of future studies will benefit if a standardised partitioning method is used.

Considerations

The results of this study are promising and we recommend the use of avian feeding guilds to be tested in a larger framework. There are, however, some issues to address. The major weakness of the current study is that we surveyed only two disturbed sites and one control site. As a result, statistical power is diminutive. With a larger number of study sites, quantitative instead of merely qualitative interpretations would be possible. The required effort can be divided over multiple observers, without yielding personally biased results. In order to compare survey data adequately, the method of surveying should be maximally standardised (e.g. time of day, time of year, time spent in the field, etc.). The time spent effectively in the field in this study varied due to logistical constraints (most importantly transportation and weather). As long as the number of species recorded appears to have reached a plateau (although not explicitly tested, expected to have occurred during our visits), this should not be a significant problem (Soberón & Llorente 1993).

SWPF and GLPF differ in the sense that the former area is relatively flat coastal rainforest, whereas the latter is located further inland and covers a wider altitudinal range. This could introduce differences other than the level of disturbance and thus potentially invalidate our results. Indeed there are floristic differences between the areas, but still SWPF and GLPF are considered to belong to the same floristic region (Slik *et al.* 2003, 2007). We have argued that the disturbed sites and the control site, despite being part of different forest tracts, are reasonably comparable in terms of their avifaunal composition. However, we recommend that in future research, as far as is logistically possible, study sites located in the same forest area be used.

It could be argued that increased ecosystem dynamics due to forest degradation could lead to an increase in species richness (Ghazoul & Hellier 2000). At the same time, however, population density within species would decrease. By including a relative abundance measure per avian feeding guild (e.g. the number of 'contacts'), a potentially clearer picture of community change can be revealed. Similarly, it would be useful to quantify the level of disturbance per study site. Comparing sites with different degrees of disturbance would provide insights in the resilience of individual avian feeding guilds.

Implementation

There is a clear need for practical monitoring tools, for example to test the effect of different management strategies. The preliminary results in this study indicate that analysing avian feeding guild structure is sensitive enough to detect even the presence of small-scale disturbance. Moreover, short surveys are a suitable method to obtain the required data. We used a horizontal approach, i.e. comparing affected areas to a 'yard-stick'. The method could just as well be applied to a vertical approach, i.e. monitoring a particular area over time. We recommend that avian feeding guilds are included in standardised monitoring programmes.

ACKNOWLEDGEMENTS

This research was financially supported by the J. J. ter Pelkwijk and Pluspunt Individu funds, and via Delta and LUSTRA scholarships of Leiden University. We thank Tropenbos International and the Tropenbos Indonesia Program for logistic support. Special thanks to the people of Pinang Jatus and Mului and the staff of Sungai Wain Management Board for their hospitality. Gabriella Fredriksson provided the total checklist of Sungai Wain Protection Forest, Bas van Balen aided with bird identification, and René Dekker provided comments on the set-up of the research. Two anonymous reviewers provided useful suggestions.

REFERENCES

van Balen, B. (1999) Differential extinction patterns in Javan forest birds. Pp.39–57 in B. van Balen, *Birds on fragmented islands: persistence in the forests of Java and Bali.* Tropical Resource Management Papers 30. Wageningen: Wageningen University and Research Centre.

Bibby, C. J., Burgess, N. D. & Hill, D. A. (2000) *Bird census techniques.* London: Academic Press.

Boorsma, T. (2008) *The impact of forest degradation on the diversity and composition of bird communities in East Kalimantan, Indonesia: a methodological study.* Report 233. Velp: Tropical Forest and Nature Management: Hogeschool Van Hall Larenstein.

Caro, T. M. & O'Doherty, G. (1999) On the use of surrogate species in conservation biology. *Conserv. Biol.* 13: 805–814.

Cleary, D. F. R., Boyle, T. J. B., Setyawati, T., Anggraeni, C. D., van Loon, E. E. & Menken, S. B. J. (2007) Bird species and traits associated with logged and unlogged forest in Borneo. *Ecol. Appl.* 17: 1184–1197.

Dickinson, E. C. ed. (2003) *The Howard and Moore complete checklist of the birds of the world.* Third edition. London: Christopher Helm.

Fredriksson, G. M. & Nijman, V. (2004). Habitat use and conservation status of two elusive ground birds (*Carpococcyx radiatus* and *Polyplectron schleiermacheri*) in the Sungai Wain Protection Forest, East Kalimantan, Indonesian Borneo. *Oryx* 38(3): 297–303.

Ghazoul, J. & Hellier, A. (2000) Setting limits to ecological indicators of sustainable tropical forestry. *Internatn. Forestry Rev.* 2: 243–253.

Gill, F. & Wright, M. (2006) *Birds of the world: recommended English names.* London: Christopher Helm.

Gray, M. A., Baldauf, S. L., Mayhew, P. J. & Hill, J. K. (2006) The response of avian feeding guilds to tropical forest disturbance. *Conserv. Biol.* 21: 133–141.

Hansen, M. C., Stehman, S. V. & Potapov, P. V. (2010) Quantification of global gross forest cover loss. *Proc. Natn. Acad. Sci.* 107: 8650–8655.

de Iongh, H. H., Pieterse, S., van Weerd, M. & Wielstra, B. (2007) Using avian guilds for monitoring Bornean lowland forests. Pp.171–196 in H. H. de Iongh, G. A. Persoon & W. Kustiawan, eds. *Options for biodiversity conservation and sustainable use in lowland forests of southeast Borneo: proceedings of a workshop organized on 19 May 2006 in Leiden, The Netherlands.* Leiden: Institute of Environmental Sciences.

Jepson, P. & Ladle, R. J. (2005) Bird-keeping in Indonesia: conservation impacts and the potential for substitution-based conservation responses. *Oryx* 39: 442–448.

Lambert, F. R. (1992) The consequences of selective logging for Bornean lowland forest birds. *Phil. Trans. Roy. Soc. London* B 335: 443–457.

Lambert, F. R. & Collar, N. J. (2002) The future of Sundaic lowland forest birds: long-term effects of commercial logging and fragmentation. *Forktail* 18: 127–146.

Meijaard, E., Sheil, D., Nasi, R., Augeri, D., Rosenbaum, B., Iskandar, D., Setyawati, T., Lammertink, M., Rachmatika, I., Wong, A., Soehartono, T., Stanley, S. & O'Brien, T. (2005) *Life after logging: reconciling wildlife conservation and production forestry in Indonesian Borneo*. Bogor, Indonesia: CIFOR.

Noss, R. F. (1999) Assessing and monitoring forest biodiversity: a suggested framework and indicators. *Forest Ecol. Mgmt.* 115: 135–146.

Parker, T. A. (1991) On the use of tape recorders in avifaunal surveys. *Auk* 108: 443–444.

Pieterse, S. & Wielstra, B. (2005) *The effects of small-scale forest disturbance by indigenous people on species diversity and community structure of birds in the Gunung Lumut Protection Forest, East Kalimantan, Indonesia.* Environment and Development Student Report 197. Leiden: Institute of Environmental Sciences.

van der Ploeg, J. & Persoon, G. (2007) ['A socio economic survey in the Gunung Lumut Forest area'] Pp.109–152 in H. H. de Iongh, G. A. Persoon & W. Kustiawan, eds. *Options for biodiversity conservation and sustainable use in lowland forests of southeast Borneo: proceedings of a workshop organized on 19 May 2006 in Leiden, The Netherlands.* Leiden: Institute of Environmental Sciences.

Root, R. B. (1967) The niche exploitation pattern of the Blue-gray Gnatcatcher. *Ecol. Monogr.* 37: 317–350.

Simberloff, D. & Dayan, T. (1991) The guild concept and the structure of ecological communities. *Ann. Rev. Ecol. Syst.* 22: 115–143.

Slik, J. W. F., Poulsen, A. D., Ashton, P. S., Cannon, C. H., Eichhorn, K. A. O., Kartawinata, K., Lanniari, I., Nagamasu, H., Nakagawa, M., van Nieuwstadt, M. G. L., Payne, J., Purwaningsih, Saridan, A., Sidiyasa, K., Verburg, R. W., Webb, C. O. & Wilkie, P. (2003) A floristic analysis of the lowland dipterocarp forests of Borneo. *J. Biogeography* 30: 1517–1531.

Slik, J. W. F. & van Balen, S. (2006) Bird community changes in response to single and repeated fires in a lowland tropical rainforest of eastern Borneo. *Biodiversity and Conservation* 15: 4425–4451.

Slik, J. W. F., Hovenkamp, P. Iqbal, M. & Raes, N. (2007) ['Structure, plant species diversity and plant species composition of the Gunung Lumut Protection Forest'] Pp.71–107 in H. H. de Iongh, G. A. Persoon & W. Kustiawan, eds. *Options for biodiversity conservation and sustainable use in lowland forests of southeast Borneo: proceedings of a workshop organized on 19 May 2006 in Leiden, Netherlands.* Leiden: Institute of Environmental Sciences.

Smythies, B. E. & Davison, G. W. H. (1999) *The birds of Borneo*. Fourth edition. Kota Kinabalu: Natural History Publications, Malaysia.

Soberón, J. & Llorente, J. (1993) The use of species accumulation functions for the prediction of species richness. *Conserv. Biol.* 7: 480–488.

Thiollay, J.-M. (1995) The role of traditional agroforest in the conservation of rainforest bird diversity in Sumatra. *Conserv. Biol.* 9: 335–353.

Wielstra, B. & Pieterse, S. M. (2009) A bird survey of Gunung Lumut Protection Forest, East Kalimantan and a recommendation for its designation as an Important Bird Area. *Kukila* 14: 1–15.

***Ben WIELSTRA**, Netherlands Centre for Biodiversity Naturalis, PO Box 9517, 2300 RA Leiden, Netherlands. Email: ben.wielstra@ncbnaturalis.nl*

***Tjalle BOORSMA**, Van Hall Larenstein University of Applied Sciences, Tropical Forest and Nature Management, Velp, Netherlands. Email: t.boorsma@yahoo.com*

***Sander M. PIETERSE**, Netherlands Centre for Biodiversity Naturalis, PO Box 9517, 2300 RA Leiden, Netherlands. Email: sander.pieterse@ncbnaturalis.nl*

***Hans H. DE IONGH**, Institute of Environmental Sciences, Department of Conservation Biology, PO Box 9518, 2300 RA Leiden, Netherlands. Email: iongh@cml.leidenuniv.nl*

Appendix

List of bird species included in the analysis and their division into avian feeding guilds

Sequence and taxonomy closely follow Dickinson (2003) and Gill & Wright (2006). SWPF = Sungai Wain Protection Forest; GLPF = Gunung Lumut Protection Forest; PJ = Pinang Jatus; M = Mului; Visit I = data from Pieterse & Wielstra (2005); Visit II = data from Boorsma (2008). Avian feeding guild is a combination of foraging layer (A = arboreal; U = understorey; T = terrestrial) and diet (F = frugivore; I = insectivore; C = carnivore; N = nectarivore; combinations possible).

Vernacular	Scientific	Avian feeding guild	SWPF total checklist	SWPF visit I	SWPF visit II	GLPF PJ visit I	GLPF PJ visit II	GLPF M visit I	GLPF M visit II
Pheasants	**Phasianidae**								
Long-billed Partridge	*Rhizathera langirastris*	**TFI**	-	-	-	-	x	-	x
Crested Partridge	*Rollulus rauloul*	**TFI**	x	x	x	-	x	x	-
Crested Fireback	*Laphura ignita*	**TFI**	x	-	x	x	x	-	-
Bornean Peacock Pheasant	*Polyplectron schleiermocheri*	**TFI**	x	x	x	x	x	-	-
Great Argus	*Argusianus argus*	**TFI**	x	x	x	x	x	x	x
Doves and pigeons	**Columbidae**								
Common Emerald Dove	*Chalcophops indico*	**TF**	x	x	x	x	x	x	x
Little Green Pigeon	*Treran alax*	**AF**	x	x	-	x	x	x	x
Pink-necked Green Pigeon	*Treran vernans*	**AF**	-	-	-	-	-	x	-
Thick-billed Green Pigeon	*Treron curvirostro*	**AF**	x	-	x	x	x	-	-
Large Green Pigeon	*Treron copellei*	**AF**	x	-	x	x	-	x	x
Jambu Fruit Dove	*Ptilinapus jambu*	**AF**	x	-	-	-	-	-	-
Green Imperial Pigeon	*Duculo oeneo*	**AF**	x	x	-	x	x	-	-
Mountain Imperial Pigeon	*Ducula badia*	**AF**	-	-	-	-	-	x	-
Parrots	**Psittacidae**								
Blue-crowned Hanging Parrot	*Lariculus galgulus*	**AN**	x	x	x	x	x	x	x
Blue-rumped Parrot	*Psittinus cyanurus*	**AF**	x	x	x	x	x	x	x
Long-tailed Parakeet	*Psittacula longicoudo*	**AF**	x	x	-	-	-	-	-
Cuckoos	**Cuculidae**								
Short-toed Coucal	*Centrapus rectunguis*	**TI**	x	x	-	x	x	x	x
Bornean Ground Cuckoo	*Corpococcyx rodiotus*	**TFI**	x	x	x	x	-	-	-
Raffles's Malkoha	*Rhinartha chlaraphaea*	**AI**	x	x	x	x	x	x	x

Vernacular	Scientific	Avian feeding guild	SWPF total checklist	SWPF visit I	SWPF visit II	GLPF PJ visit I	GLPF PJ visit II	GLPF M visit I	GLPF M visit II
Red-billed Malkoha	*Zonclostomus jovonicus*	AI	x	x	x	x	x	-	-
Chestnut-breasted Malkoha	*Phaenicaphaeus curvirostris*	AI	x	-	x	x	x	x	x
Black-bellied Malkoha	*Phaenicophoeus diordi*	AI	x	-	x	-	-	x	x
Chestnut-bellied Malkoha	*Phoenicophoeus sumatranus*	AI	x	-	-	x	x	-	-
Violet Cuckoo	*Chrysacaccyx xonthorhynchus*	AI	x	x	-	x	-	x	x
Little Bronze Cuckoo	*Chrysococcyx minutillus*	AI	x	-	-	-	-	-	-
Banded Bay Cuckoo	*Cocomontis sonnerotii*	AI	x	x	x	-	x	x	x
Square-tailed Drongo Cuckoo	*Surniculus lugubris*	AI	x	x	-	x	-	x	x
Moustached Hawk Cuckoo	*Hieracoccyx vogons*	UI	-	-	-	-	-	-	x
Malaysian Hawk Cuckoo	*Hierocaccyx fugox*	UI	x	-	-	-	-	-	-
Indian Cuckoo	*Cuculus micropterus*	AI	x	x	x	x	-	x	x
Trogons	**Trogonidae**								
Red-naped Trogon	*Horpoctes kosumbo*	UI	x	x	-	x	x	-	x
Diard's Trogon	*Horpactes diardii*	UI	x	x	x	x	x	x	x
Cinnamon-rumped Trogon	*Horpoctes orrhophoeus*	UI	x	-	-	-	-	-	-
Scarlet-rumped Trogon	*Horpoctes duvoucelii*	UI	x	x	-	x	x	x	x
Kingfishers	**Alcedinidae**								
Rufous-collared Kingfisher	*Actenaides cancretus*	UIC	x	x	-	-	-	-	-
Banded Kingfisher	*Locedo pulchello*	UI	x	x	x	-	-	-	-
Oriental Dwarf Kingfisher	*Ceyx erithaca*	UIC	x	x	x	x	x	x	x
Blue-banded Kingfisher	*Alcedo euryzono*	UIC	x	-	-	-	-	-	x
Blue-eared Kingfisher	*Alceda meninting*	UIC	x	x	x	x	x	-	-
Bee-eaters	**Meropidae**								
Red-bearded Bee-eater	*Nyctyornis amictus*	AI	x	x	-	-	x	x	x
Hornbills	**Bucerotidae**								
Bushy-crested Hornbill	*Anarrhinus goleritus*	AFC	x	x	x	x	x	x	x
Oriental Pied Hornbill	*Anthracaceras albirostris*	AFC	-	-	-	x	x	-	-
Black Hornbill	*Anthrococeros moloyonus*	AFC	x	x	x	x	x	-	x
Rhinoceros Hornbill	*Buceros rhinoceras*	AFC	x	x	x	x	x	x	x
Helmeted Hornbill	*Rhinaplax vigil*	AFC	x	-	x	x	x	x	x
White-crowned Hornbill	*Berenicornis camatus*	AFC	x	-	-	x	-	-	-
Wrinkled Hornbill	*Aceros corrugotus*	AFC	x	x	x	x	x	x	x
Wreathed Hornbill	*Rhyticeros undulatus*	AFC	x	x	x	x	x	x	x
Asian barbets	**Megalaimidae**								
Golden-whiskered Barbet	*Megalaimo chrysopagon*	AF	x	-	-	x	x	x	x
Red-crowned Barbet	*Megoloima rafflesii*	AFI	x	x	x	-	x	-	x
Red-throated Barbet	*Megoloima mystacaphanos*	AFI	x	-	x	x	x	x	x
Yellow-crowned Barbet	*Megoloimo henricii*	AF	-	-	-	x	x	x	x
Blue-eared Barbet	*Megalaimo oustrolis*	AF	x	x	x	x	x	x	x
Brown Barbet	*Calarhamphus fuliginosus*	AFI	x	x	x	x	x	x	x
Honeyguides	**Indicatoridae**								
Malaysian Honeyguide	*Indicotor archipelagicus*	AI	x	-	-	x	-	-	-
Woodpeckers	**Picidae**								
Rufous Piculet	*Sosio obnarmis*	AI	x	x	x	x	x	x	x
Grey-capped Pygmy Woodpecker	*Dendrocopus canicapillus*	AI	x	x	-	x	x	x	x
Rufous Woodpecker	*Celeus brochyurus*	UI	x	x	x	-	-	x	x
White-bellied Woodpecker	*Dryacapus javensis*	AI	x	x	x	x	-	x	-
Banded Woodpecker	*Picus mineaceus*	UI	x	-	-	x	-	x	-
Crimson-winged Woodpecker	*Picus puniceus*	AI	x	x	x	x	-	x	x
Checker-throated Woodpecker	*Picus mentalis*	AI	x	x	-	-	-	-	-
Olive-backed Woodpecker	*Dinopium rofflesii*	UI	x	x	-	x	-	x	x
Maroon Woodpecker	*Blythipicus rubiginasus*	UI	x	x	x	x	x	x	x
Orange-backed Woodpecker	*Reinwordtipicus validus*	AI	x	-	x	x	x	x	x
Buff-rumped Woodpecker	*Meiglyptes tristis*	AI	x	x	x	x	x	x	x
Buff-necked Woodpecker	*Meiglyptes tukki*	UI	x	x	x	-	x	x	-
Grey-and-buff Woodpecker	*Hemicircus cancretus*	AI	x	x	x	x	x	x	x
Great Slaty Woodpecker	*Mulleripicus pulverulentus*	AI	x	x	x	x	x	-	x
Broadbills	**Eurylaimidae**								
Green Broadbill	*Colyptomeno viridis*	AF	x	-	x	x	x	x	-
Black-and-red Broadbill	*Cymbirhynchus macrarhynchos*	AI	x	x	x	x	x	x	-
Banded Broadbill	*Euryloimus javanicus*	AI	x	x	x	x	x	x	x
Black-and-yellow Broadbill	*Euryloimus ochramalus*	AI	x	x	x	x	x	x	x
Dusky Broadbill	*Carydan sumatronus*	AI	x	x	x	x	x	x	x
Pittas	**Pittidae**								
Giant Pitta	*Pitto coerulea*	TI	-	-	-	x	-	-	-
Banded Pitta	*Pitto guajono*	TI	x	-	-	x	x	-	x
Blue-banded Pitta	*Pitto orquoto*	TI	-	-	-	-	x	-	x
Garnet Pitta	*Pitto gronatina*	TI	x	x	x	x	x	-	x

Vernacular	Scientific	Avian feeding guild	SWPF total checklist	SWPF visit I	SWPF visit II	GLPF PJ visit I	GLPF PJ visit II	GLPF M visit I	GLPF M visit II
Blue-headed Pitta	*Pitto boudii*	TI	x	-	-	x	x	-	-
Hooded Pitta	*Pitto sordida*	TI	x	-	x	x	x	x	x
Australian warblers	**Acanthizidae**								
Golden-bellied Gerygone	*Gerygane sulphureo*	AI	x	x	-	x	-	-	-
Woodshrikes and allies	**Tephrodornithidae**								
Black-winged Flycatcher-shrike	*Hemipus hirundinaceus*	AI	x	x	x	x	x	x	x
Large Woodshrike	*Tephradarnis virgatus*	AI	x	x	-	-	-	-	x
Rufous-winged Philentoma	*Philentama pyrhaptera*	UI	x	x	x	x	x	x	x
Maroon-breasted Philentoma	*Philentama velata*	UI	x	-	x	-	x	-	x
Bornean Bristlehead	**Pityriasidae**								
Bornean Bristlehead	*Pityriasis gymnocephola*	AFI	x	-	-	-	-	-	-
Ioras	**Aegithinidae**								
Common Iora	*Aegithina tiphia*	AI	x	x	-	x	-	-	-
Green Iora	*Aegithina viridissima*	AI	x	x	x	x	-	x	x
Cuckooshrikes	**Campephagidae**								
Bar-bellied Cuckooshrike	*Coracino strioto*	AI	x	x	x	-	-	-	-
Lesser Cuckooshrike	*Caracina fimbriata*	AI	x	x	x	x	x	x	x
Fiery Minivet	*Pericracatus igneus*	AI	x	-	-	-	-	-	-
Scarlet Minivet	*Pericracatus flammeus*	AI	x	x	x	x	x	x	x
Whistlers	**Pachycephalidae**								
Mangrove Whistler	*Pochycepholo grisolo*	AI	x	-	-	-	-	-	-
Vireos	**Vireonidae**								
White-bellied Erpornis	*Erparnis zanthaleuca*	AI	x	-	-	-	-	-	-
Orioles	**Oriolidae**								
Dark-throated Oriole	*Orialus xanthanatus*	AFI	x	x	x	x	x	x	x
Drongos	**Dicruridae**								
Bronzed Drongo	*Dicrurus oeneus*	AI	x	x	-	-	x	x	x
Hair-crested Drongo	*Dicrurus hottentottus*	AI	x	-	x	-	-	-	-
Greater Racket-tailed Drongo	*Dicrurus paradiseus*	UI	x	x	x	x	x	x	x
Fantails	**Rhipiduridae**								
Spotted Fantail	*Rhipiduro perloto*	UI	x	x	x	-	x	x	x
Monarchs	**Monarchidae**								
Black-naped Monarch	*Hypothymis azurea*	UI	x	x	x	x	x	x	x
Asian Paradise Flycatcher	*Terpsiphane paradisi*	UI	x	x	x	x	x	x	x
Crows and jays	**Corvidae**								
Crested Jay	*Platylaphus galericulatus*	UI	x	x	x	-	-	x	x
Black Magpie	*Platysmurus leucapterus*	AFI	x	x	x	x	x	-	x
Slender-billed Crow	*Carvus enca*	AFI	x	x	x	x	x	x	x
Malay Rail-babbler	**Eupetidae**								
Malaysian Rail-babbler	*Eupetes macracerus*	TI	x	-	-	-	-	-	-
Fairy flycatchers	**Stenostiridae**								
Grey-headed Canary Flycatcher	*Culicicopo ceylonensis*	UI	x	x	x	-	x	-	x
Bulbuls	**Pycnonotidae**								
Black-and-white Bulbul	*Pycnanatus melanaleucas*	AFI	x	-	x	-	-	x	x
Black-headed Bulbul	*Pycnonotus otriceps*	AFI	x	x	x	x	x	x	x
Scaly-breasted Bulbul	*Pycnanotus squamotus*	AFI	-	-	-	-	-	-	x
Grey-bellied Bulbul	*Pycnonotus cyoniventris*	AFI	x	-	-	-	-	-	-
Puff-backed Bulbul	*Pycnonotus eutilotus*	UFI	x	x	x	x	x	x	x
Cream-vented Bulbul	*Pycnonatus simplex*	UFI	x	x	-	-	-	x	-
Asian Red-eyed Bulbul	*Pycnonotus brunneus*	UFI	x	x	x	x	x	x	x
Spectacled Bulbul	*Pycnanatus erythrapthalmus*	UFI	x	x	x	x	x	x	x
Grey-cheeked Bulbul	*Alophoixus bres*	UFI	x	x	x	x	x	x	x
Yellow-bellied Bulbul	*Alaphaixus phaeacephalus*	UFI	x	x	x	x	x	-	x
Hairy-backed Bulbul	*Tricholestes criniger*	UFI	x	x	x	-	x	-	-
Buff-vented Bulbul	*Iale alivacea*	UFI	x	x	x	x	-	x	x
Streaked Bulbul	*Ixos moloccensis*	AFI	x	x	-	-	-	-	-
***Cettia* bush warblers and allies**	**Cettidae**								
Yellow-bellied Warbler	*Abrascapus superciliaris*	AI	x	x	-	-	x	x	x
Cisticolas and allies	**Cisticolidae**								
Dark-necked Tailorbird	*Orthatamus atragularis*	UI	x	x	x	x	x	-	x
Rufous-tailed Tailorbird	*Orthotomus sericeus*	UI	x	x	x	x	x	x	x
Ashy Tailorbird	*Orthatamus ruficeps*	UI	x	x	x	x	x	x	x
Babblers	**Timaliidae**								
Black-capped Babbler	*Pellarneum capistratum*	TI	x	x	x	x	x	x	x

Vernacular	Scientific	Avian feeding guild	SWPF total checklist	SWPF visit I	SWPF visit II	GLPF PJ visit I	GLPF PJ visit II	GLPF M visit I	GLPF M visit II
White-chested Babbler	*Trichostoma rostratum*	TI	x	x	x	-	x	x	-
Ferruginous Babbler	*Trichostoma bicolor*	UI	x	x	x	x	x	x	x
Abbott's Babbler	*Malacocincla abbotti*	UI	x	x	-	-	-	-	-
Horsfield's Babbler	*Malacocincla sepiaria*	UI	x	x	x	-	-	-	-
Short-tailed Babbler	*Malacocincla malaccensis*	TI	x	x	x	x	x	x	x
Moustached Babbler	*Malacopteron magnirostre*	UI	x	x	x	-	-	-	x
Sooty-capped Babbler	*Malacopteron affine*	UI	x	x	-	x	x	x	-
Scaly-crowned Babbler	*Malacopteron cinereum*	UI	x	x	x	x	x	-	x
Rufous-crowned Babbler	*Malacopteron magnum*	UI	x	x	x	x	x	x	x
Grey-breasted Babbler	*Malacopteron albogulare*	UI	x	x	x	-	-	-	-
Chestnut-backed Scimitar Babbler	*Pomatorhinus montanus*	UFI	x	x	x	-	x	x	x
Bornean Wren Babbler	*Ptilocichla leucogrammica*	TI	x	-	-	-	-	-	-
Striped Wren Babbler	*Kenopia striata*	TI	x	x	x	-	-	-	-
Black-throated Wren Babbler	*Napothera atrigularis*	TI	-	-	-	-	x	x	-
Rufous-fronted Babbler	*Stachyris rufifrons*	UI	x	x	x	-	-	-	-
Grey-headed Babbler	*Stachyris poliocephala*	UI	-	-	-	-	-	x	x
Chestnut-rumped Babbler	*Stachyris maculata*	UI	x	x	x	x	x	x	-
Black-throated Babbler	*Stachyris nigricollis*	UI	x	x	x	x	x	x	x
Chestnut-winged Babbler	*Stachyris erythroptera*	UI	x	x	x	x	x	x	x
Bold-striped Tit Babbler	*Macronus gularis*	UI	x	x	x	x	x	x	x
Fluffy-backed Tit Babbler	*Macronous ptilosus*	UI	x	x	x	x	x	x	x
Brown Fulvetta	*Alcippe brunneicauda*	UFI	x	x	x	-	x	x	x
Fairy-bluebirds	**Irenidae**								
Asian Fairy-bluebird	*Irena puella*	AF	x	x	x	x	x	x	x
Nuthatches	**Sittidae**								
Velvet-fronted Nuthatch	*Sitta frontalis*	AI	x	x	x	x	-	-	-
Starlings	**Sturnidae**								
Common Hill Myna	*Gracula religiosa*	AF	x	x	x	x	x	x	x
Thrushes	**Turdidae**								
Chestnut-capped Thrush	*Zoothera interpres*	UFI	-	-	-	-	-	-	x
Chats and Old World flycatchers	**Muscicapidae**								
White-rumped Shama	*Copsychus malabaricus*	UI	x	x	x	x	x	x	x
Rufous-tailed Shama	*Trichixos pyrrhopygus*	UI	x	x	x	-	-	-	-
Chestnut-naped Forktail	*Enicurus ruficapillus*	TI	x	-	-	-	x	-	-
White-crowned Forktail	*Enicurus leschenaulti*	TI	x	x	x	x	-	-	x
Grey-chested Jungle Flycatcher	*Rhinomyias umbratilis*	UI	x	x	x	x	x	-	-
Rufous-chested Flycatcher	*Ficedula dumetoria*	UI	x	x	x	-	x	-	-
Verditer Flycatcher	*Eumyias thalassinus*	AI	-	-	-	-	-	x	x
Pale Blue Flycatcher	*Cyornis unicolor*	AI	x	-	-	-	-	-	-
Sunda Blue Flycatcher	*Cyornis caerulatus*	UI	x	-	-	-	-	-	-
Bornean Blue Flycatcher	*Cyornis superbus*	AI	x	-	-	-	-	-	-
Malaysian Blue Flycatcher	*Cyornis turcosus*	UI	x	x	x	x	-	-	-
Dark Blue Flycatcher	*Cyornis concretus*	UI	-	-	-	-	x	-	-
Leafbirds	**Chloropseidae**								
Greater Green Leafbird	*Chloropsis sonnerati*	AN	x	-	x	x	x	x	x
Lesser Green Leafbird	*Chloropsis cyanopogon*	AN	x	x	x	x	-	x	x
Blue-winged Leafbird	*Chloropsis cochinchinensis*	AN	x	x	x	x	-	x	x
Flowerpeckers	**Dicaeidae**								
Yellow-breasted Flowerpecker	*Prionochilus maculatus*	AFI	x	x	-	x	-	x	x
Yellow-rumped Flowerpecker	*Prionochilus xanthopygius*	UN	x	x	x	x	x	x	x
Yellow-vented Flowerpecker	*Dicaeum chrysorrheum*	AN	x	-	-	-	-	-	x
Orange-bellied Flowerpecker	*Dicaeum trigonostigma*	AN	x	-	-	x	x	x	x
Plain Flowerpecker	*Dicaeum concolor*	AN	x	-	-	-	-	-	-
Scarlet-backed Flowerpecker	*Dicaeum cruentatum*	AN	x	-	-	-	-	-	-
Sunbirds and spiderhunters	**Nectariniidae**								
Ruby-cheeked Sunbird	*Chalcoparia singalensis*	UN	x	x	x	x	x	x	x
Plain Sunbird	*Anthreptes simplex*	AN	x	-	-	x	-	x	x
Red-throated Sunbird	*Anthreptes rhodolaemus*	UN	-	-	-	-	-	-	x
Purple-naped Sunbird	*Hypogramma hypogrammicum*	UN	x	x	x	x	x	x	x
Purple-throated Sunbird	*Leptocoma sperata*	AN	x	-	-	x	x	-	x
Crimson Sunbird	*Aethopyga siparaja*	AN	x	-	-	x	x	-	-
Temminck's Sunbird	*Aethopyga temminckii*	AN	x	-	-	-	-	-	-
Little Spiderhunter	*Arachnothera longirostra*	UN	x	x	x	x	x	x	x
Thick-billed Spiderhunter	*Arachnothera crassirostris*	AN	x	-	-	-	-	-	-
Long-billed Spiderhunter	*Arachnothera robusta*	AN	x	-	-	-	-	-	-
Spectacled Spiderhunter	*Arachnothera flavigaster*	AN	x	-	-	x	x	x	x
Yellow-eared Spiderhunter	*Arachnothera chrysogenys*	UN	x	-	-	-	-	x	-
Grey-breasted Spiderhunter	*Arachnothera modesta*	UN	x	x	-	-	x	x	x
			169	**120**	**110**	**113**	**111**	**105**	**115**